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(72) Inventors:
• **NEUMAIER, Christoph**
85625 Baiern (DE)
• **BAUMGARTNER, Bernhard**
83620 Feldkirchen-Westerham (DE)
• **LANDINGER, Josef**
83229 Aschau (DE)
• **PRÖCKL, Thomas**
83043 Bad Aibling (DE)

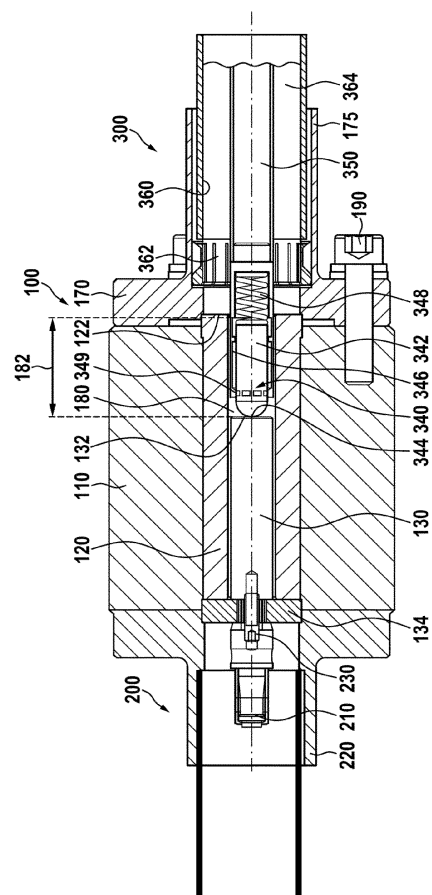
(71) Applicant: **Spinner GmbH**
80335 München (DE)

(74) Representative: **Lohr, Jöstingmeier & Partner**
Junkersstraße 3
82178 Puchheim/München (DE)

(54) **RF CONNECTOR WITH ARC SUPPRESSION**

(57) A coaxial connector system includes a main body and a load connector. The main body has a cylindrical bore holding an insulating tube which further holds a cylindrical center conductor. This conductor has at one end a contact area which is recessed for a recess distance within the tube such that an arcing space is formed. The load connector has an inner conductor with a center contact pin which is configured to protrude into the insulating tube and to establish a contact with the center conductor.

Fig. 1



Description

Field of the invention

[0001] The invention relates to a coaxial RF connector system which can be connected or disconnected under high power load.

Description of the related art

[0002] A coaxial RF connector system is disclosed in EP 3 300 535 A1. This connector system can couple comparatively high RF power up to a few Kilowatts. For connecting and/or disconnecting, the power must be switched off. If these connectors are connected or disconnected under load, arcing may occur which may lead to a severe damage of the connectors. Further, there are no precautions to avoid an early connection between the center conductors during connecting or a late disconnection of the center conductors while disconnecting, specifically due to arcing. A center connector contact without shield or ground contact may incur a safety risk, as an ungrounded section of the conductor system may be at a high voltage. This may be harmful for persons operating the connectors.

Summary of the invention

[0003] The problem to be solved by the invention is to provide an RF connector system which is capable of transferring high power RF signals in the range of several Kilowatts and in a broad frequency range between 1 Megahertz and multiple GHZ, but not limited to that range. This coaxial connector system should be connectable and/or disconnectable when an RF signal is applied on one side, which may be either the male or the female connector. This connection/disconnection must be electrically safe and must not damage any of the connectors.

[0004] Solutions of the problem are described in the independent claims. The dependent claims relate to further improvements of the invention.

[0005] In an embodiment, a coaxial connector system may include a main body and a load connector. The main body may have a cylindrical bore holding an insulating tube which further holds a cylindrical main center conductor. This forms a coaxial system, where the main body is the outer conductor. This coaxial system may have a required characteristic impedance, e.g., 50 Ohm. The insulating tube may fit exactly between the main center conductor and the main body, such that there is no or only a marginal air gap. This may avoid partial discharges under high voltages. The main center conductor has at one end a main contact area, which is configured to provide a contact with a center conductor of the load connector. This main contact area is recessed for a recess distance from a first end of the tube and within the tube. This forms an arcing space between the main contact area and the first end of the tube. As such, the arcing

area is located deeply in the tube. It is surrounded by the insulating material of the tube which may be any suitable dielectric material, e.g., PTFE or any other suitable material. It may be beneficial to use high temperature-resistant materials, like polyimide or others, as these may better withstand high temperatures which may occur during arcing.

[0006] The load connector may also include a coaxial conductor system with an outer conductor and an inner conductor, which may also be spaced by a spacing tube. The inner conductor has a center contact pin or is attached to a center contact pin which is configured to enter into contact with the main center conductor. For this purpose, the center contact pin is configured to protrude into the insulating tube, until it reaches the recessed end of the main center conductor and establishes a contact therewith at the main contact area. The main contact area of the main center conductor and/or the center contact pin may include a suitable contact material which further may withstand high temperatures and/or arcing. This may be a silver alloy including nickel and/or cadmium, or any other heat-resistant material, like tungsten.

[0007] The center pin may be loaded by a spring to ensure a proper contact force between the contact pin and the main center conductor. Further, there may be a limit stop to prevent a too far extension of the contact pin. For connecting the load connector, this is simply plugged into the main body such that the center contact pin protrudes into the insulating tube and enters into contact with the main center conductor. The outer conductor of the load connector may have contact springs or spring elements to provide a good contact to the main body or a contact sleeve, which may be part of an outer flange which further may be attached to the main body.

[0008] A contact sleeve, which is configured to establish an electrical contact to the outer conductor of the load connector (by means of the outer conductor connector) may improve security. When connecting the load connector to the main body, the outer conductors are connected first and when disconnecting, the outer conductors are connected last. In an embodiment, the length of the contact sleeve is configured such, that the outer conductor of the load connector is in contact with the contact sleeve as long as the center contact pin reaches at least partially into the insulating tube.

[0009] When disconnecting the connector under load, e.g., when a power source is connected to either side or both sides, arcing may occur when the center contact pin is removed from the main center conductor. The arc generates hot ionized gases which are kept within the insulating tube. For this purpose, the recess distance of the insulating tube must be long enough to provide a sufficient space for hot gases. Further, the insulating tube may extend with its first end over the main body, such that no arc can establish from the hot gases of the interior of the tube to its outside and to the main body. To reduce arcing, it may be desired to cool down the hot gases as much as possible. For this purpose, the cylindrical main

center conductor may be a solid body of metal providing a high thermal conductivity and a high thermal capacitance. Furthermore, the center contact pin may also include a solid piece of metal. Further, it is preferred if the main center conductor has a certain minimum length which enables it to dissipate heat through the insulating tube to the main body. As the insulating tube, which may include an electrically insulating or dielectric material, is with a high probability therefore thermal insulating, it is difficult to transfer heat from the main center conductor to the main body. Accordingly, a long main center conductor may be used.

[0010] In an embodiment, the main center conductor is connected to a source connector inner conductor which is coaxial to a source connector outer conductor. The source connector outer conductor may form a circular waveguide and exceeds the length of the source connector inner conductor preferably of at least one half or one wavelength of a signal transmitted.

[0011] In an embodiment, a pneumatic actuator is provided. The center contact pin may be replaced by a pneumatic piston operated center contact pin. It may include a pneumatic piston section and a contact pin section which may be a single (monolithic) part or separated parts, e.g., having a contact section and a piston rod section. The pneumatic piston operated center contact pin may be held in an essentially coaxial tube forming the center conductor. An outer conductor may be coaxially surrounding the center conductor. The outer conductor may be slidable in a contact sleeve or fixedly mounted to the main body.

[0012] There may be a contact sleeve to provide a good electrical contact between the center contact pin and the center conductor.

[0013] At least one piston is part of or mounted to the center contact pin and seals against the interior of center conductor. The pistons can move along a common center axis of the center contact pin and the center conductor. The pistons may be operated by gas pressure provided through first and second gas ducts. The gas ducts may include dielectric insulating material and may further hold the center conductor within the outer conductor. Although one piston may be sufficient, two pistons are shown which provide a better support of the contact pin. The gas may be any type of gas. Air and nitrogen are well suited. A gas like argon may be used, as this may also help to quench or extinguish any arc at the electrical contact.

[0014] To close the electrical connection, the center conductor may be moved to a close position by providing gas pressure through the second gas ducts, filling first chambers, and pressing the pistons to a first side. For opening the electrical connection, the center conductor may be moved to an opposing side by providing gas pressure through the first gas ducts, filling second chambers, and pressing the pistons to the opposing side.

[0015] There may be a mechanical lock including at least one locking lever. The at least one locking lever may snap into a recess or groove in the pneumatic piston

operated center contact pin, when the contact pin is in a closed position (first side). It may also lock into a second recess or groove in the pneumatic piston operated center contact pin, when the contact pin is in an open position (opposing side). The at least one locking lever may include a spring or other elastic element to hold the locking lever in a position engaged with the contact pin. There may be at least one release pin which may press on the at least one locking lever to release the locking lever and therefore to allow the contact pin to move. The release pin may be operated manually through a flexible outer conductor by pressing on the outer conductor.

Description of Drawings

[0016] In the following the invention will be described by way of example, without limitation of the general inventive concept, on examples of embodiment with reference to the drawings.

Figure 1 shows a connector system.

Figure 2 shows a schematic with dimensions.

Figure 3 shows arcing paths.

Figure 4 shows an embodiment with a pneumatic actuator.

Figure 5 shows a front view of the pneumatic actuator.

[0017] In Figure 1, a connector system 100 is shown. It includes a main body 110 with a coaxial conductor structure and an arcing space. It is contacted by a source connector 200 and a removable load connector 300, which may be disconnected while power is provided at the source connector and/or power is provided at the load connector.

[0018] In an embodiment, the connector system includes a main body 110 holding an insulating tube 120. The main body 110 may include an electrically conductive material, like a metal which may be copper, brass, or aluminum. It may further be coated or galvanized by a highly conductive material e.g., silver, gold, or an alloy including one of these. The insulating tube may include a dielectric material which is suitable for radio frequencies. This may for example be PTFE. In an embodiment, the insulating tube includes a heat resistant dielectric material like polyimide which can withstand higher temperatures which are generated by arcs during connecting and/or disconnecting of the connector system. Within the insulating tube 120 is a main center conductor 130. This may include a conductive material, like copper, brass, aluminum, or any other suitable material, which may be coated or galvanized with a highly conductive material like e.g., silver, gold, or an alloy including one of these. The main center conductor 130 may include a solid cylinder of a material or metal, which may provide a comparatively high thermal capacity to absorb heat which is developed by arcs. It may further have a certain minimum length to provide a larger outer surface area which allows

to dissipate heat through the insulating tube 120 to the main body 110 which may be of a thermally conductive material. The main center conductor 130 may be held in place by a dielectric support 134.

[0019] The main center conductor has a main contact area 132 at one end. This main contact area 132 may include or may be coated with a specific heat-resistant and/or arc-resistant material. Such a material may e.g., be tungsten or a silver alloy further including e.g., nickel and/or cadmium. The main contact area may be a planar surface, or it may be a surface with a large radius of 10 cm or more. The main contact area 132 is recessed within the insulating tube 120 at a distance 182 to form an arcing space 180 within the insulating tube 120. Within this arcing space, arcs may develop when opening or closing the electrical contact when RF-power is applied to the connector system. This arcing space 180 is within the insulating tube such that no arc may develop from a center conductor to an outer conductor due to hot ionized gases.

[0020] The main contact area 132 is contacted by a center contact pin 340 which may be part of the load connector 340. This pin 340 may have a pin body 342 which may be held by a guide sleeve 346 and further has a center contact area 344 at its tip, which is configured to contact the main contact area 132. For providing a defined contact force, a spring 348 may be provided which may press the center contact pin 340 against the main center conductor 130. The center contact pin 340 may also include a heat-resistant and/or arc-resistant material.

[0021] The center contact pin 340 may have a depth stop or limit stop 349, such that it may only extend a few millimeters from the guide sleeve 346, which may be sufficient for providing an electrical contact when properly inserted into the insulating tube. The depth stop may prevent a long arc when disconnecting the connectors due to a long extension of the center contact pin.

[0022] The load connector 300 may include a center conductor 350, which may contact the center contact pin 340. It may further include an outer conductor 360 spaced from the center conductor 350 by a spacing tube 364. The outer conductor 360 may have an outer conductor connector 362 which may include a plurality of contact springs to contact a contact sleeve 175. The outer conductor may include a spacer 366 which may be a ring of an insulating material, e.g., a plastic material which may easily slide along the contact sleeve 175. The contact sleeve 175 may be one part with the main body 110 or it may be attached to the main body 110, e.g., by an outer flange 170. The outer flange 170 may be screwed to the main body by screws 190. The contact sleeve 175 may be configured to contact the outer conductor 360 of the load connector 300 when the center contact pin 340 protrudes at least partially into the insulating tube 120. Further, the contact sleeve 175 may have an inner length 177 which is larger than the recess distance 182.

[0023] A source connector 200 may include an inner

conductor 210 and an outer conductor 220. There may be an inner connector contact 230. The outer conductor 220 may be extended in its length as shown or longer. In the case, the source connector 200 is disconnected and power is fed from the load connector 300 (in reverse direction), this may be radiated by a normal RF connector as source connector. Such radiation of high power may be harmful to persons handling the device. The extended length outer conductor acts as a circular waveguide, in which TEM waves coming from the load connector cannot propagate and therefore blocks or at least significantly reduces reverse RF power from the load connector. The source connector outer conductor (220) may exceed in its length the source connector inner conductor (210) preferably of at least one half or one wavelength of a signal transmitted. This solution may also be used alone, without the connector system 100, but significantly reduces the safety of the connector system 100, when combined with it.

[0024] In Figure 2 a schematic with dimensions is shown. As mentioned above, the inner length 177 of the contact sleeve 175 may be larger than the recess distance 182. Here, the inner length 177 is the length, which may be used to establish a contact between the outer conductor 360 and the contact sleeve 175. This relationship of lengths may ensure, that the outer conductor 360 is in contact with the contact sleeve 175 before it enters the insulating tube 120.

[0025] Figure 3 shows arcing paths. The shortest arcing path 401 in disconnected or OFF state is from the main center conductor along the insulating tube 120 to the main body or a part thereof outside the insulating tube 120. There may be a connector arcing path 402 between the main center conductor 130 and the center contact pin 340. If the connector arcing path is longer than the shortest arcing path, with a high probability, an arc will first establish on the shortest arcing path. Therefore, the load connector is safe, even without a connection of the outer conductor 360 to the contact sleeve 175 if it is distant enough. Before coming too close, an outer conductor connection is established to provide a proper current return path and to avoid high RF voltage at the outside of the load connector assembly and parts connected thereto.

[0026] Figure 4 shows an embodiment having a pneumatic actuator in a side cut view. Here, the center contact pin 340 of figure 1 is replaced by a pneumatic piston operated center contact pin 520. It may include a pneumatic piston section and a contact pin section which may be a single (monolithic) part or separated parts, e.g., having a contact section 520 and a piston rod section 526. The contact pin section may further have a contact element 528, which may include a contact material with low resistive contact properties and/or arc proofness. The pneumatic piston operated center contact pin 520 may be held in an essentially coaxial tube forming the center conductor 530. An outer conductor 510 is coaxially surrounding the center conductor 530. The outer conductor

may be slidable in a contact sleeve 175 or fixedly mounted to the main body.

[0027] There may be a contact sleeve 532 to provide a good electrical contact between the center contact pin 520 and the center conductor 530.

[0028] At least one piston 522, 524 is part of or mounted to the center contact pin 520 and seals against the interior of center conductor 530. The pistons can move along a common center axis 580 of the center contact pin 520 and the center conductor 530. The pistons are operated by gas pressure provided through first and second gas ducts 542, 543, 544, 545. The gas ducts may include dielectric insulating material and may further hold the center conductor 530 within the outer conductor 510. Although one piston may be sufficient, two pistons are shown which provide a better support of the contact pin. The gas may be any type of gas. Air and nitrogen are well suited. An inert gas like argon may be used, as this may also help to quench or extinguish any arc at the electrical contact. Such an inert gas may also be provided by an inert gas duct 590.

[0029] To close the electrical connection, the center conductor 530 may be moved to left side in figure 4 by providing gas pressure through the second gas ducts 544, 545, filling first chambers 552, 554 and pressing the pistons 522, 524 to the left. For opening the electrical connection, the center conductor 530 may be moved to right side in figure 4 by providing gas pressure through the first gas ducts 542, 543, filling second chambers 553, 555 and pressing the pistons 522, 524 to the right.

[0030] There may be a mechanical lock including at least one locking lever 562. The at least one locking lever 562 may snap into a recess or groove in the pneumatic piston operated center contact pin 520, when the contact pin is in a closed position (left side). It may also lock into a second recess or groove in the pneumatic piston operated center contact pin 520, when the contact pin is in an open position (right side). The at least one locking lever may include a spring or other elastic element to hold the locking lever in a position engaged with the contact pin. There may be at least one release pin 564 which may press on the at least one locking lever to release the locking lever and therefore to allow the contact pin to move. The release pin may be operated manually through a flexible outer conductor 510 by pressing on the outer conductor 510.

[0031] Figure 5 shows the previous embodiment in a front view.

List of reference numerals

[0032]

100	connector system
110	main body
120	insulating tubes
122	first end of tube
130	main center conductor

132	main contact area
134	dielectric support
170	outer flange
175	contact sleeve
5 177	inner length of contact sleeve
180	arcing space
182	recess distance
190	mounting screw
200	source connector
10 210	source connector inner conductor
220	source connector outer conductor
230	source contact
300	load connector
340	center contact pin
15 342	pin body
344	center contact area
346	guide sleeve
348	spring
349	limit stop
20 350	center conductor
360	outer conductor
362	outer conductor connector
364	spacing tube
366	spacer
25 401	shortest disconnected arcing path
402	connector arcing path to load connector
500	pneumatic actuator
510	outer conductor
520	pneumatic piston operated center contact pin
30 522,524	piston
526	piston rod
528	contact element
530	center conductor
35 532	contact sleeve
542,543	first gas ducts
544, 545	second gas ducts
552,554	first chambers
553, 555	second chambers
40 562	locking lever
564	release pin
580	center axis
590	inert gas duct

Claims

1. A coaxial connector system (100) including a main body (110) and a load connector (300),

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the main body (110) having a cylindrical bore holding an insulating tube (120) further holding a cylindrical main center conductor (130) having at one end a main contact area (132) being recessed for a recess distance (182) within the insulating tube and forming an arcing space (180) between the main contact area (132) and a first end (122) of the insulating tube, located

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- in the insulating tube,
the load connector (300) having an outer conductor (360) and an inner conductor (350) spaced from each other, the inner conductor (350) having a center contact pin (340) which is configured to protrude into the insulating tube (120) through the first end (122) and to establish a contact with the main center conductor (130) at the main contact area (132).
2. Coaxial connector system (100) according to claim 1,
characterized in, that
the main body (110) comprises a contact sleeve (175) which is configured to contact the outer conductor (360) of the load connector (300).
3. Coaxial connector system (100) according to the previous claim,
characterized in, that
the contact sleeve (175) is configured to contact the outer conductor (360) of the load connector (300) when the center contact pin (340) protrudes at least partially into the insulating tube (120).
4. Coaxial connector system (100) according to any of the previous two claims,
characterized in, that
the contact sleeve (175) has an inner length (177) which is larger than the recess distance (182).
5. Coaxial connector system (100) according to any of the previous claims,
characterized in, that
the recess distance (182) is larger than the diameter of the main center conductor (130).
6. Coaxial connector system (100) according to any of the previous claims,
characterized in, that
the outer conductor (360) comprises an outer conductor connector (262) which may further include at least one contact spring.
7. Coaxial connector system (100) according to any of the previous claims,
characterized in, that
the insulating tube (120) comprises a heat resistant dielectric material.
8. Coaxial connector system (100) according to any of the previous claims,
characterized in, that
the center contact pin (340) is loaded by a spring (348).
9. Coaxial connector system (100) according to any of the previous claims,
characterized in, that
the center contact pin (340) comprises a limit stop (349).
10. Coaxial connector system (100) according to any of the previous claims,
characterized in, that
the main contact area (132) of the main center conductor (130) includes a heat-resistant and/or arc-resistant material.
11. Coaxial connector system (100) according to any of the previous claims,
characterized in, that
the center contact pin (340) includes a heat-resistant and/or arc-resistant material.
12. Coaxial connector system (100) according to any of the previous claims,
characterized in, that
the main center conductor (130) includes a solid body of metal.
13. Coaxial connector system (100) according to any of the previous claims,
characterized in, that
a pneumatic piston operated center contact pin (520) is provided, which comprises a piston rod (526) with at least one piston (522, 524), guided in a hollow center conductor (530).
14. Coaxial connector system (100) according to the previous claim,
characterized in, that
at least one gas duct (542, 543, 544, 545) is provided to feed gas into the center conductor (530) and to move the at least one piston.
15. Coaxial connector system (100) according to the previous claim,
characterized in, that
the main center conductor (130) is connected to a source connector inner conductor (210) which

is coaxial to a source connector outer conductor (220), wherein the source connector outer conductor (220) forms a circular waveguide and exceeds in its length the source connector inner conductor (210) preferably of at least one half or one wavelength of a signal transmitted. 5

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Fig. 1

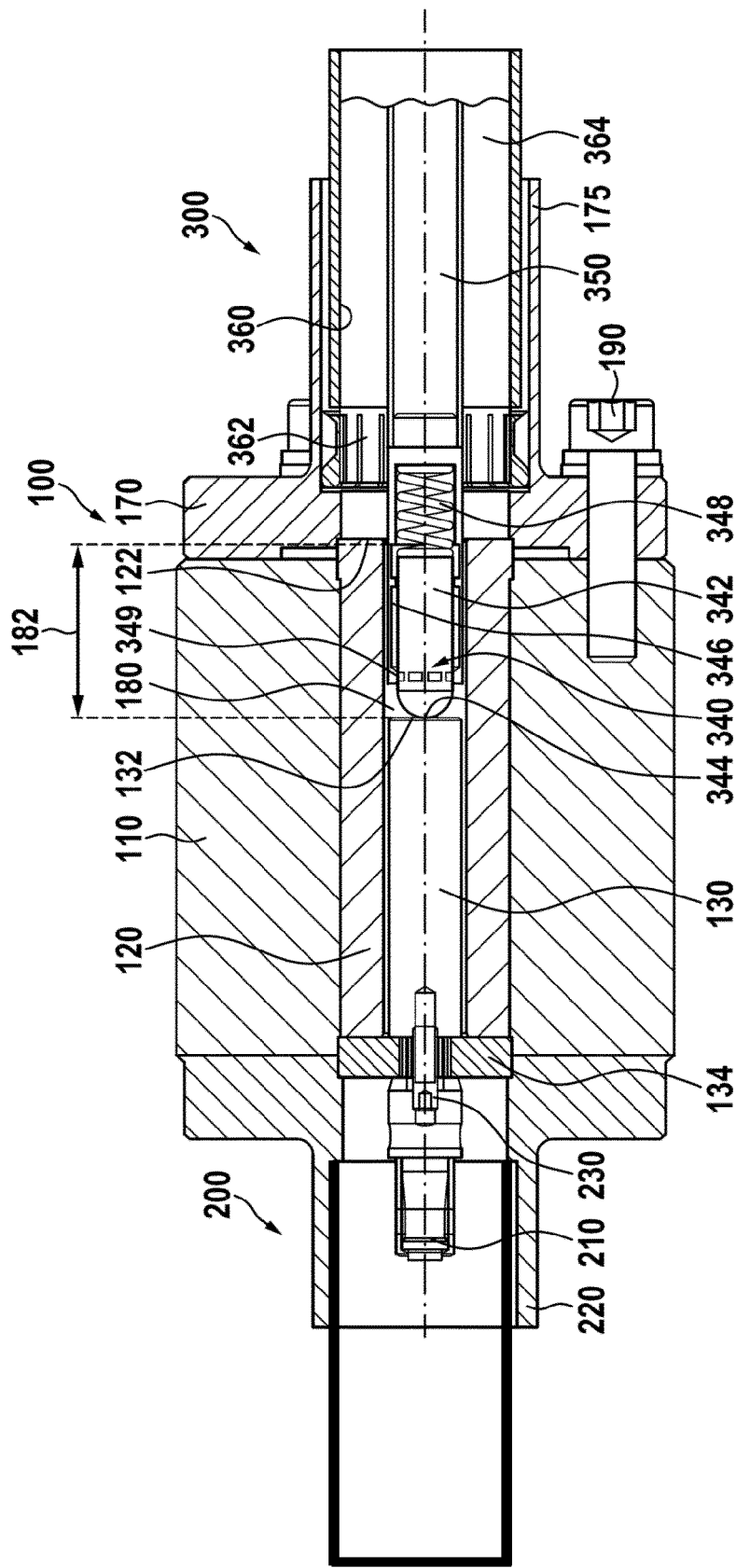


Fig. 2

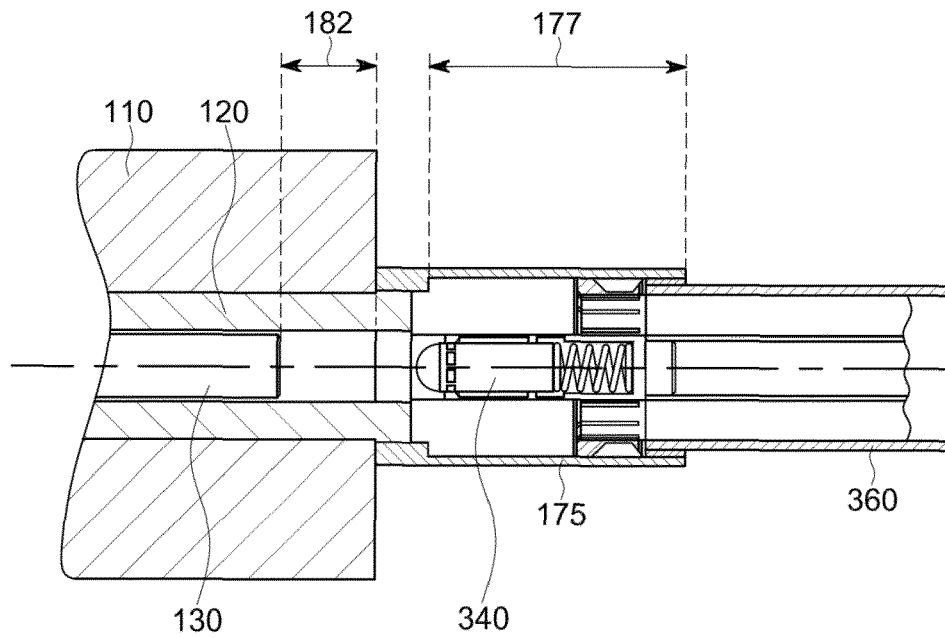


Fig. 3

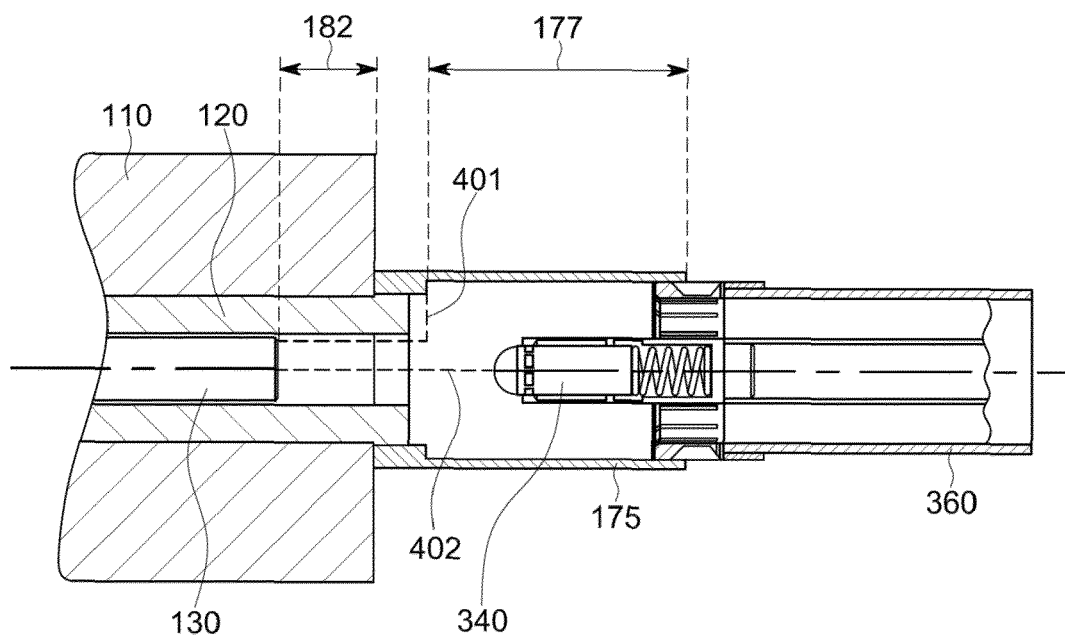


Fig. 4

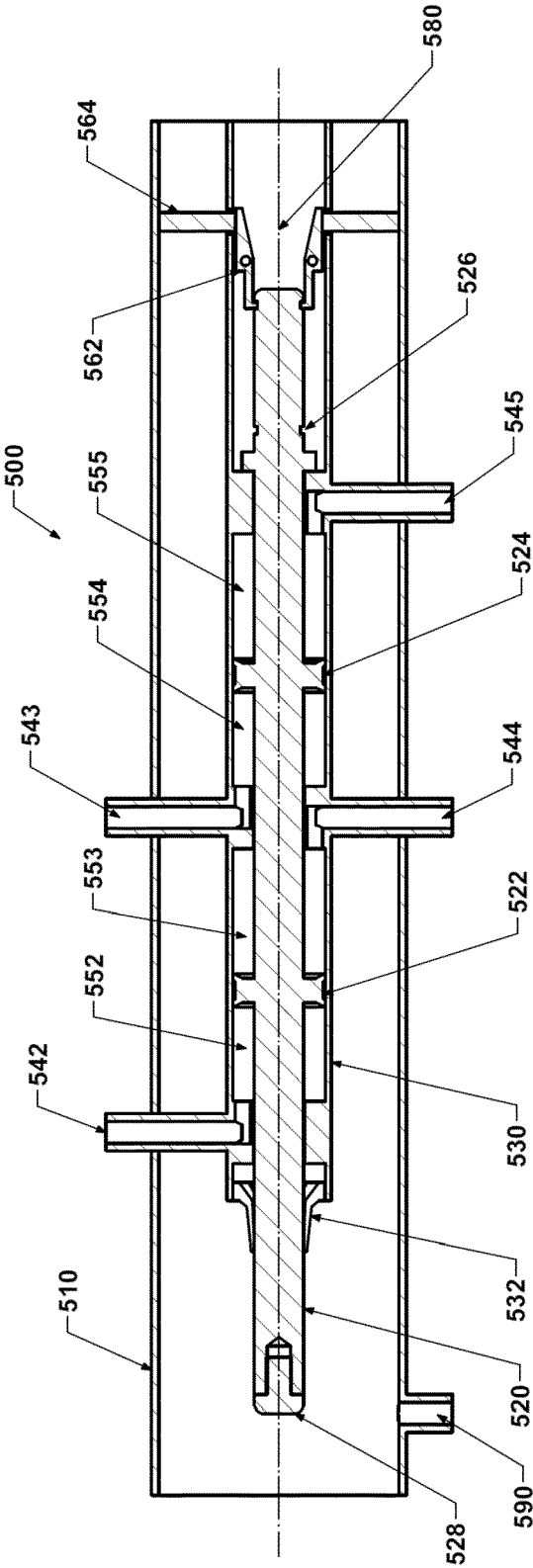
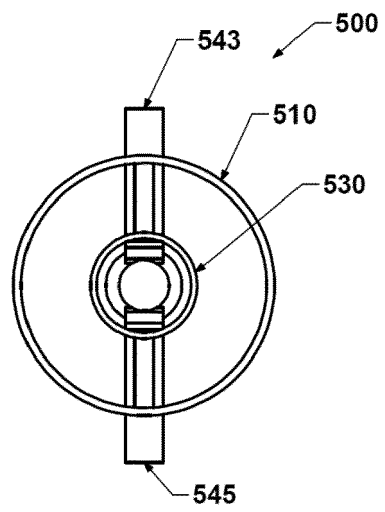


Fig. 5





EUROPEAN SEARCH REPORT

Application Number

EP 21 19 1786

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EPO FORM 1503 03.82 (P04C01)

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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